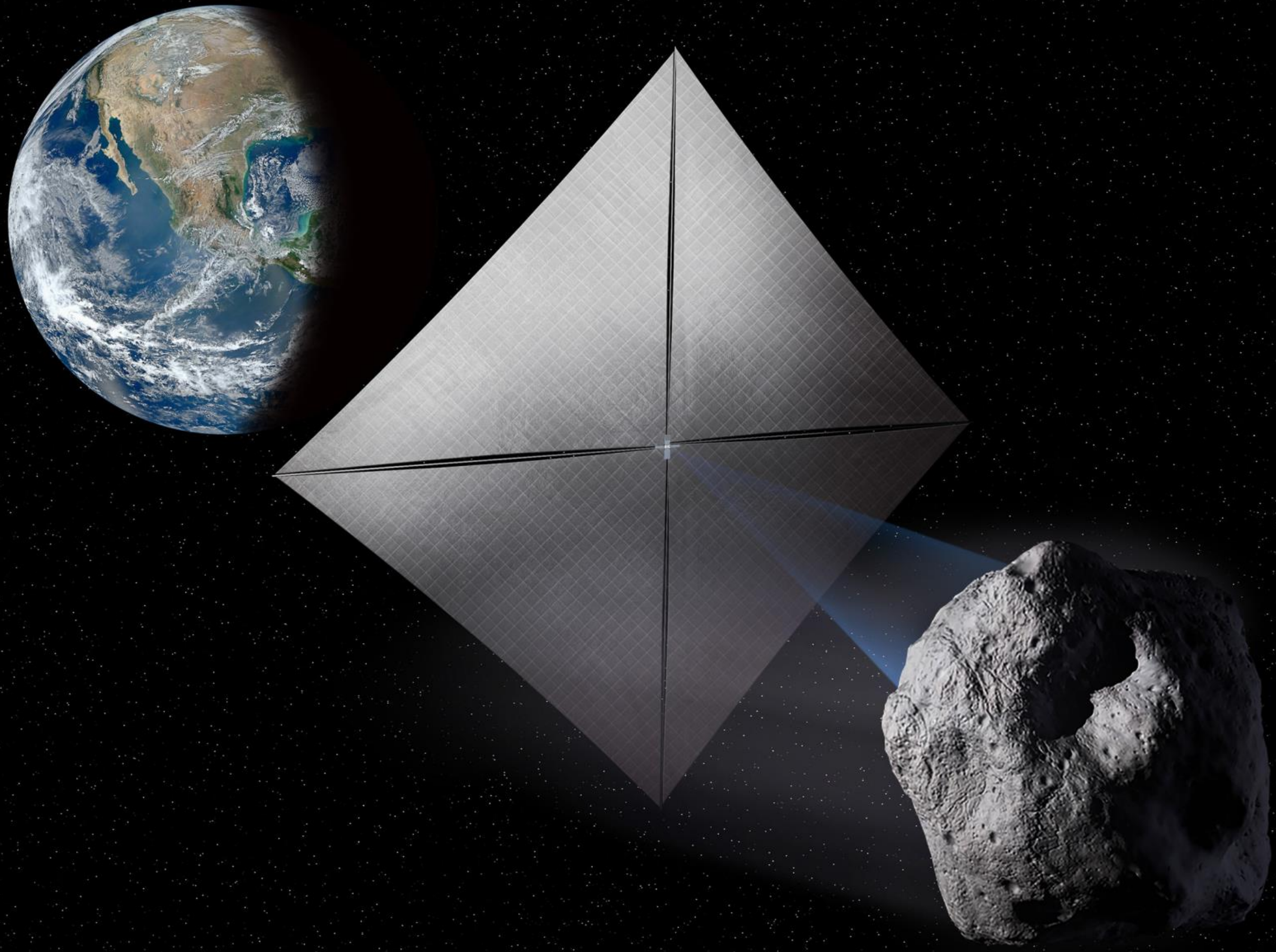
New Moon Explorer (NME) CubeSat Mission Concept

Planetary CubeSat Symposium
June 27, 2019



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Target Overview

- 2016HO3 is a Near-Earth companion representing the closest, most stable quasi-satellite to Earth
- Discovered by Pan-STARRS on April 27, 2016
- 40-100 meters in diameter
- Earth MOID 0.0348 AU (5.25 M km)
- Fast rotator with an estimated rotational period of 0.467 hours

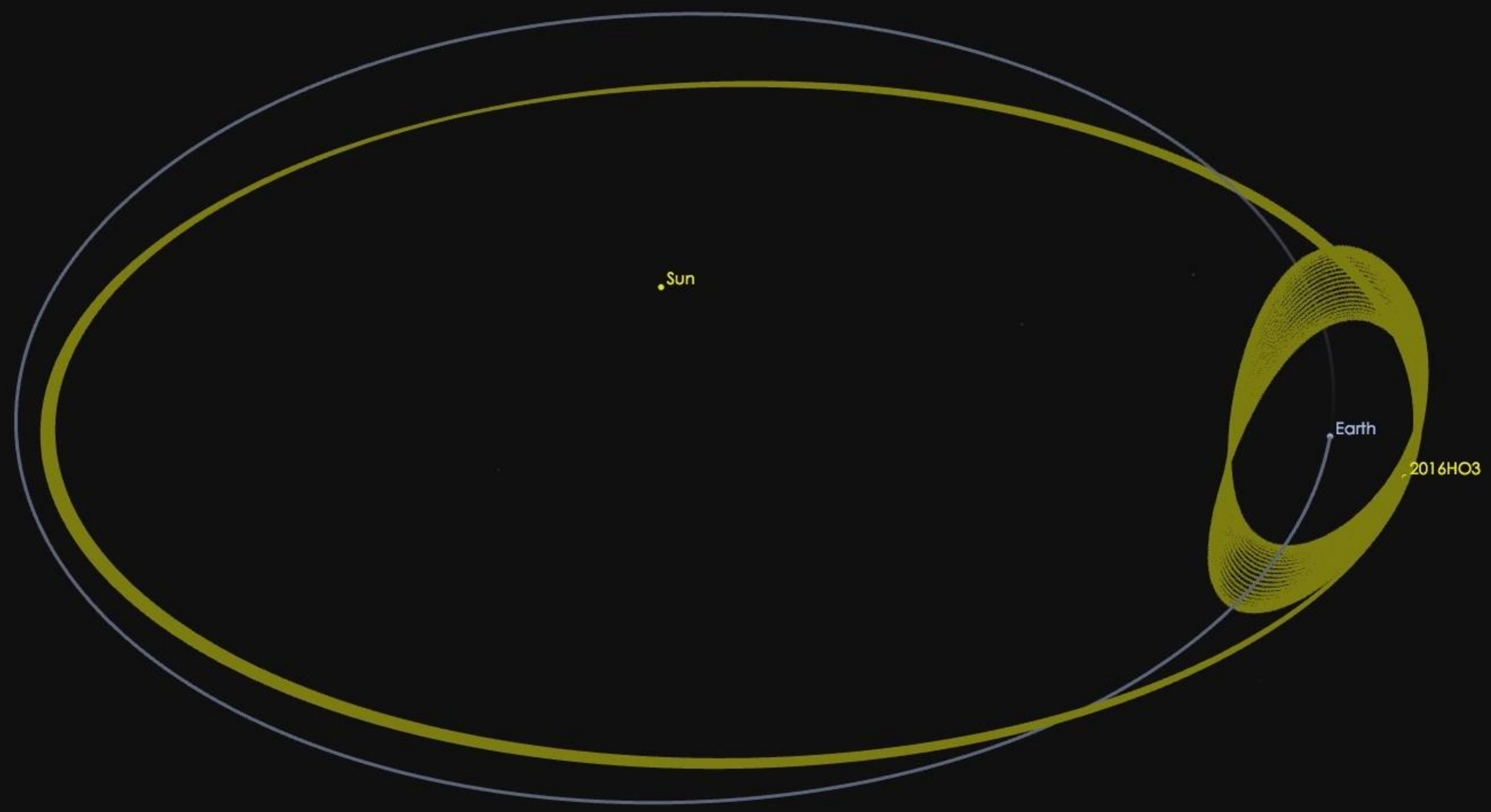


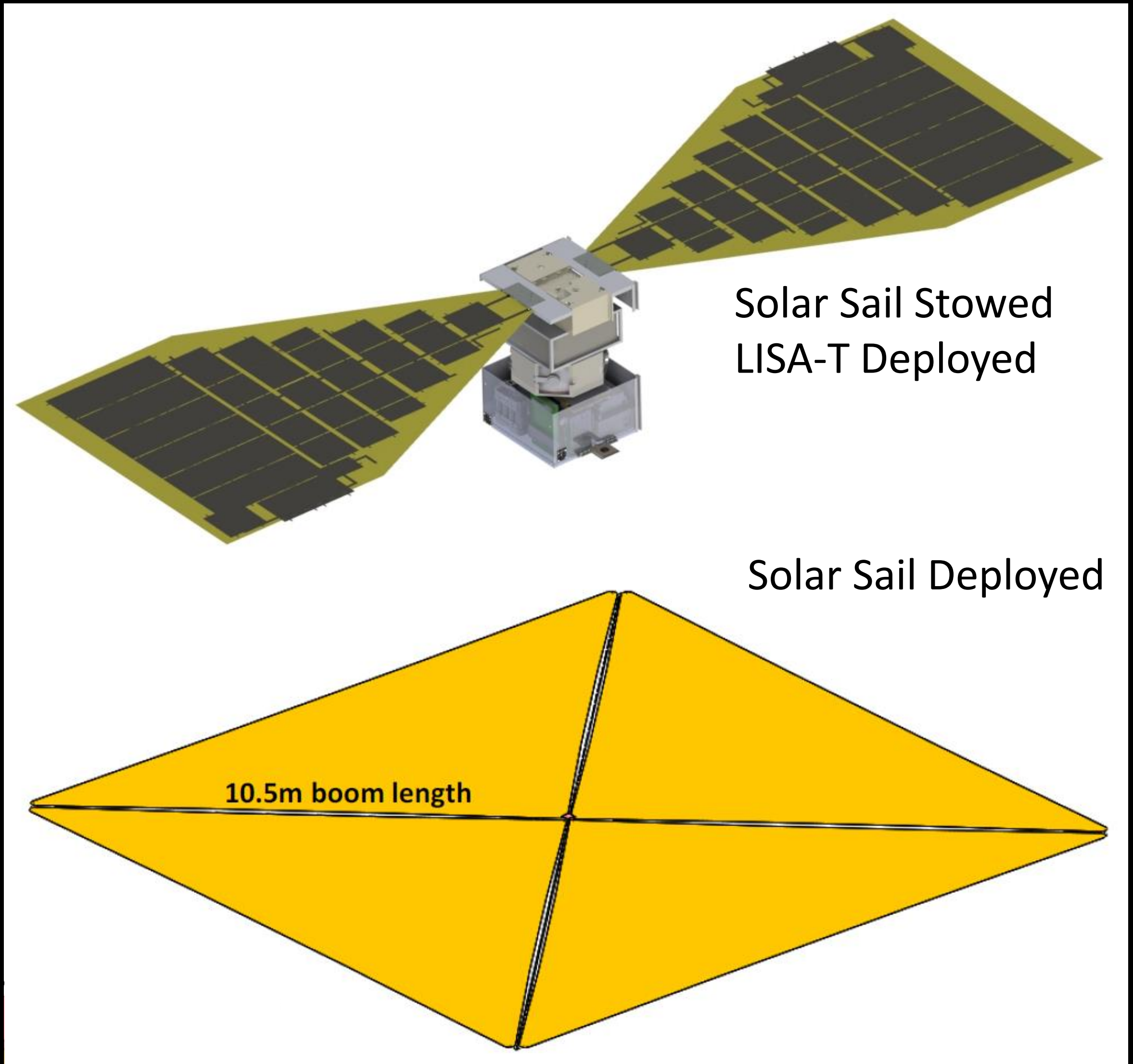
Image: JPL

Mission/Science Objectives

- Science Objectives
  - Observe Earth's 'new moon', the newly discovered near-Earth companion 2016HO3
  - Obtain spin rate, pole position, shape, structure, mass, density, chemical composition, temperature, thermal inertia, regolith characteristics, and spectral type
  - Radio science to determine precise mass and internal structure of the asteroid, preferably during close Earth flyby
- Technology Objectives
  - Continue incremental development of solar sail technology
  - Demonstrate use of thin-film power technologies
- Strategic Objectives
  - Address synergies across multiple NASA and industry needs

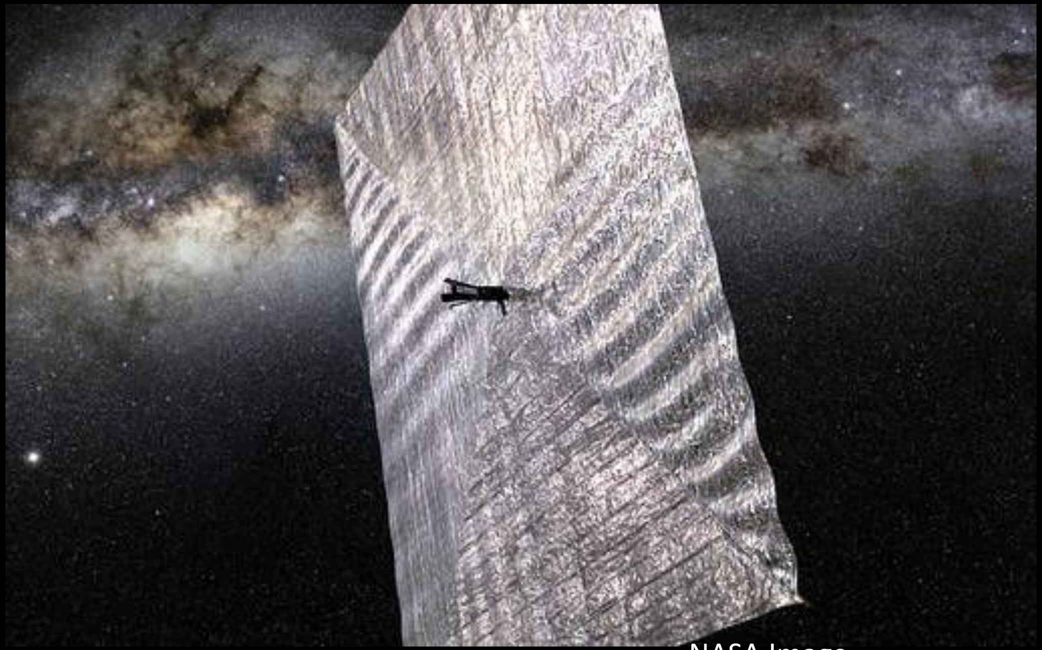
Spacecraft Features

- Low-cost 12U form factor
- Solar Sail propelled
  - 200 m^2 toughened CP1 quadrant configuration
  - 4x 10.5-m Slit-tube composite booms laminate designed using Roccor Solar Sail Tool (SST)
  - Active Mass Translator MMS
- Planar, bi-pedal 'LISA-T' for power generation and telecommunications
- Deep space CubeSat avionics as utilized on MarCO (launched 2018) and NEA Scout and IceCube missions (launch 2020)
- Cold gas for momentum desaturations and impulsive events
- Leverages developmental lessons learned from the NEA Scout mission

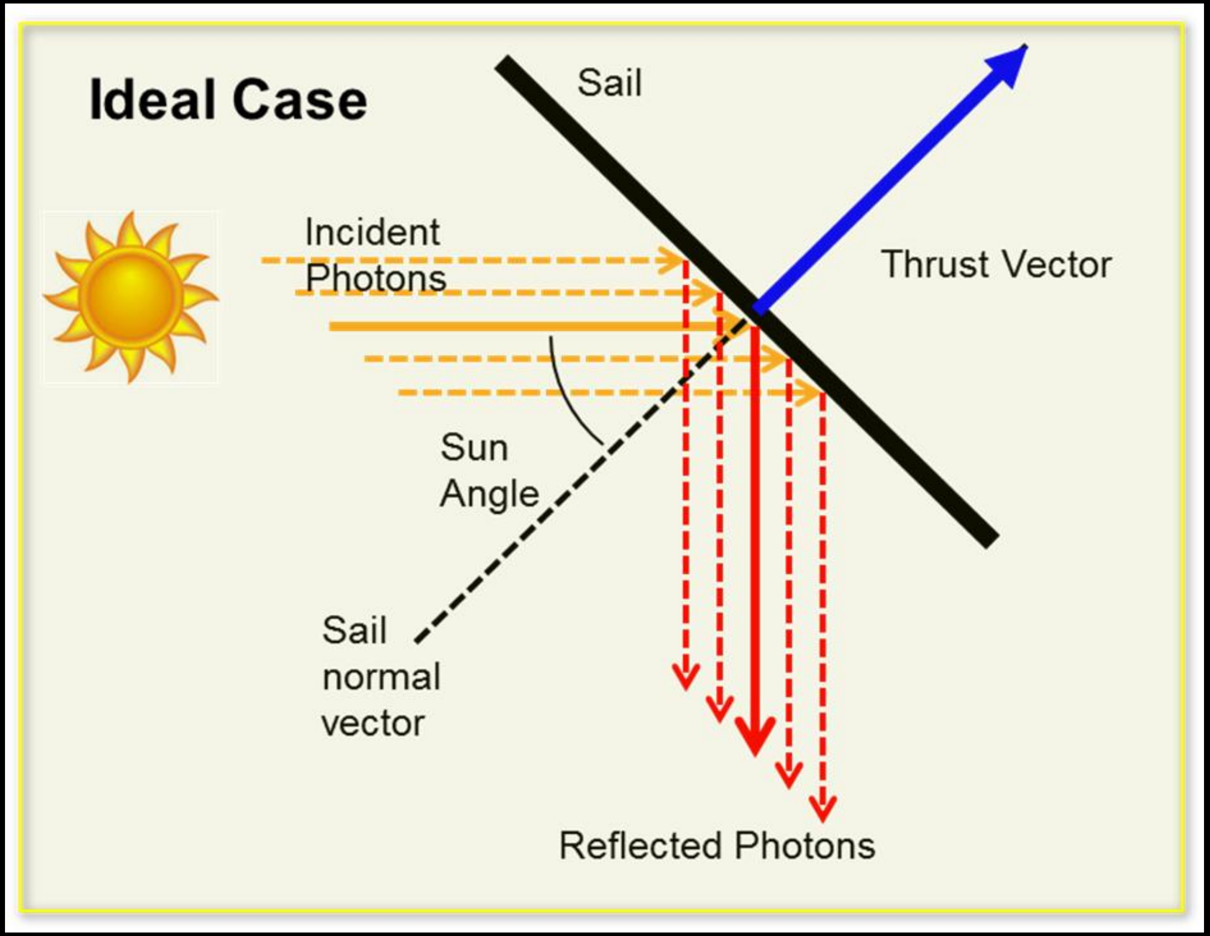


Solar Sails Derive Propulsion By Reflecting Photons

Solar sails use photon pressure on thin, lightweight, reflective sheets to produce thrust.

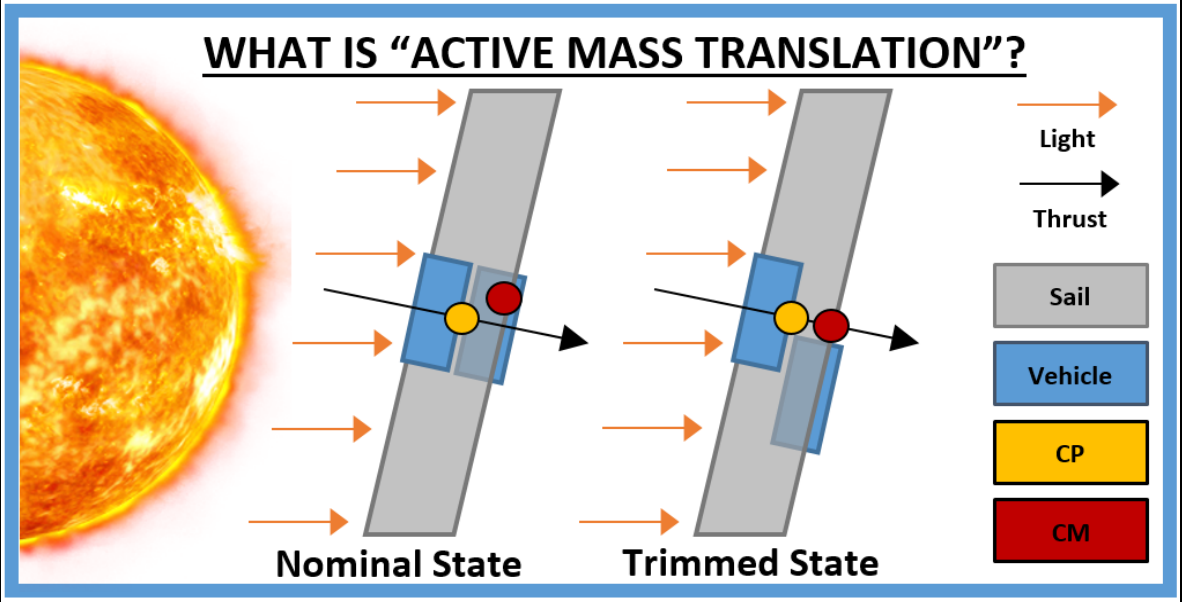


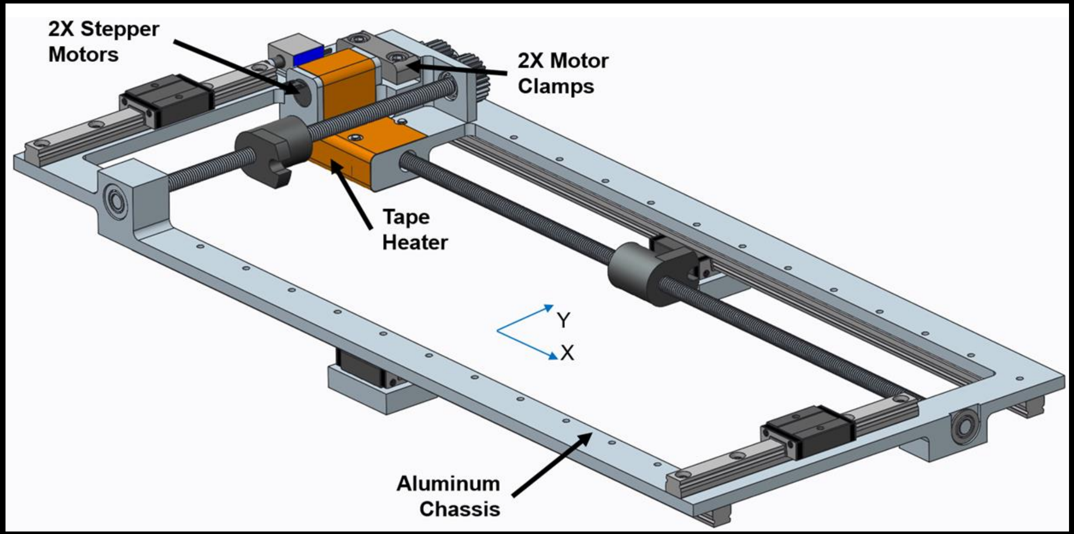
NASA Image



Momentum Management System

- Solar Radiation Pressure imparts a persistent torque on the spacecraft for the duration of the mission
- Use of expendable propellant to maintain desired Solar Sail attitude and/or desaturate reaction wheels would be mission limiting, particularly in small form factors
- A momentum management system is needed to accompany a solar sail concept
- NEA Scout utilizes Active Mass Translation (right) while IKAROS utilized Liquid Crystal Devices

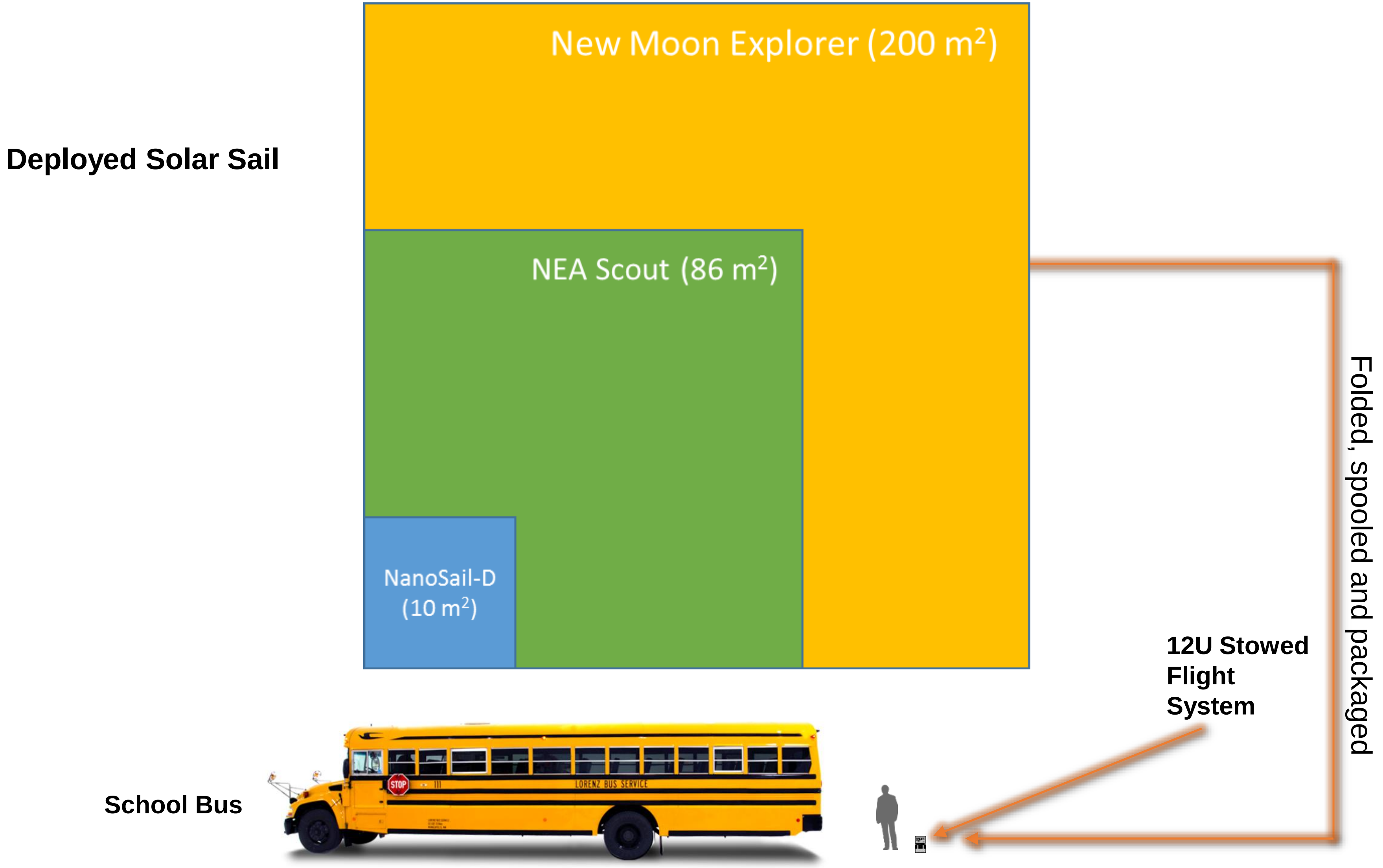




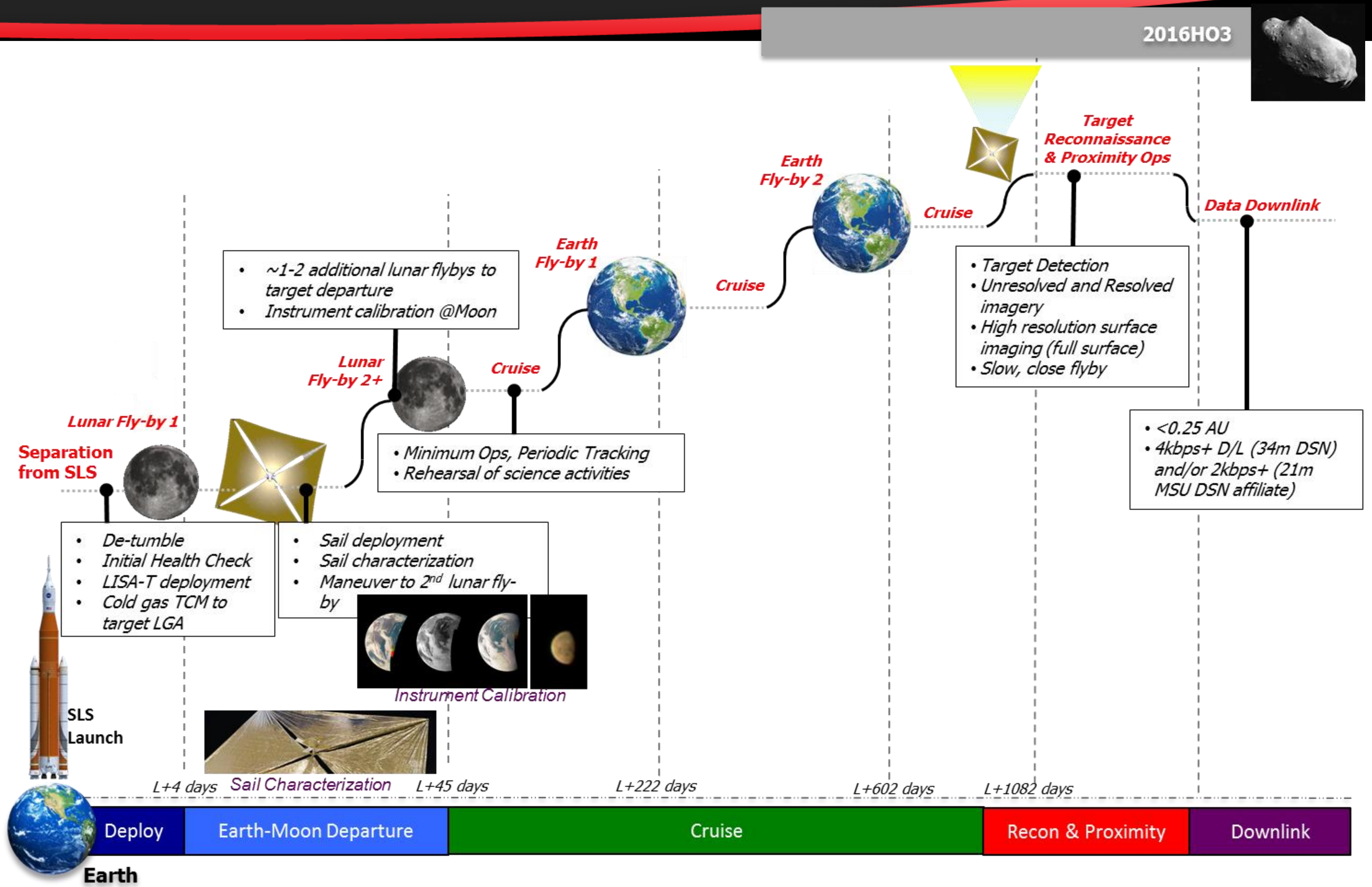
Thin-Film Power Generation

- Leverages technology development from Lightweight Solar Array and anTenna (LISA-T)
- Thin-film photovoltaics coated with polyimide and solvent bonded on Toughened CP1
- Cells electrically interconnected via micro-welded ribbons and embedded traces
- Placed on independent substrate and deployed (can be integral to Solar Sail)
- Phased array antenna can be similarly embedded resulting in integrated propellantless propulsion, power generation, and telecommunications capability

Deployed Solar Sail Approximate Scale

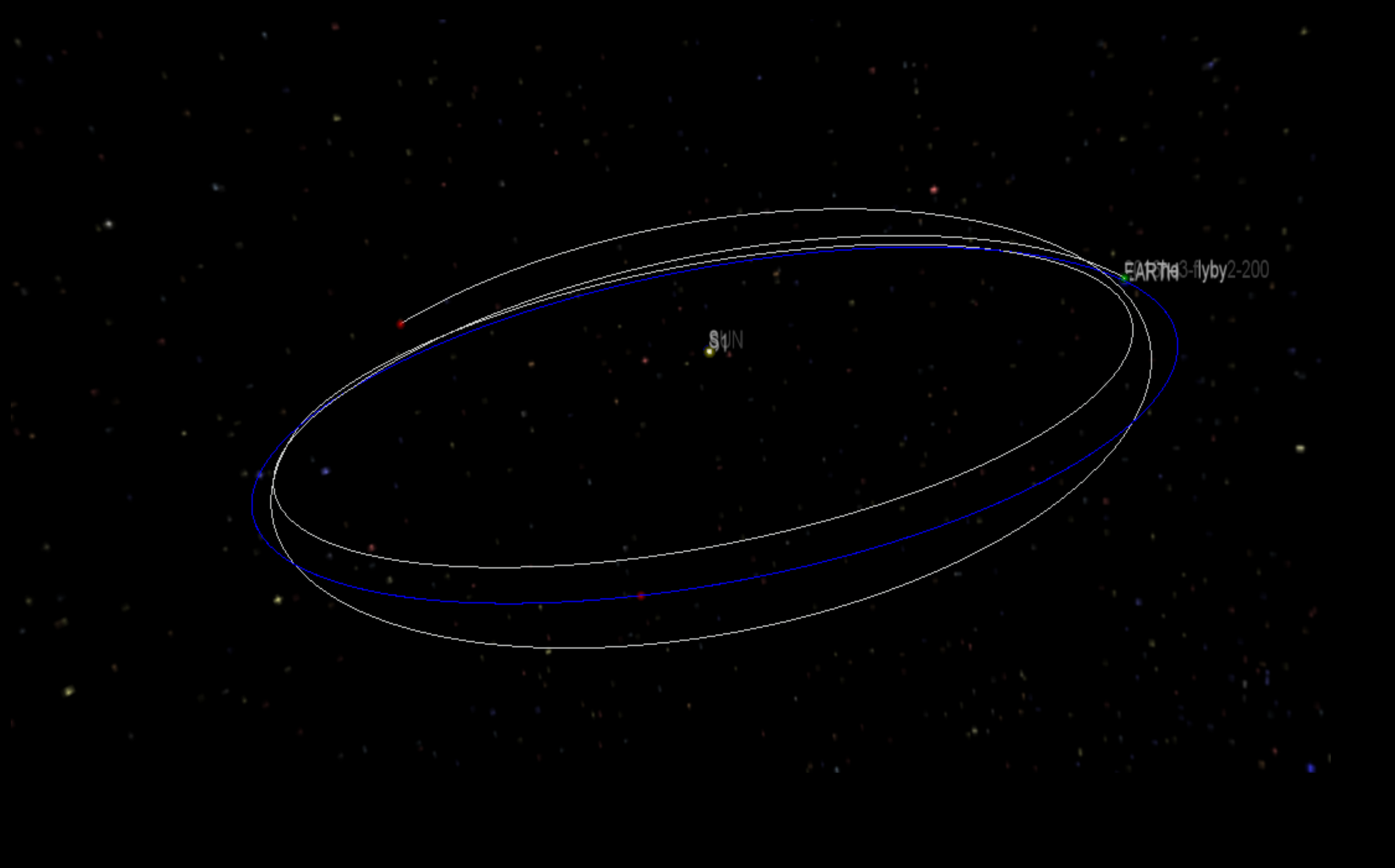


Concept of Operations



Mission Design

Event	Mission Elapsed Time (Days)	Notes
Deployment	0	Shortly after EUS disposal maneuver
Trajectory Correction Maneuver	0.5	With cold gas RCS
Sail Deploy	7	Sail calibration phase of 5 days follows deploy
Earth-Moon Escape	45	Departure C3 of 1.20 km^2/sec^2
First Earth Gravity Assist	223	Flyby Altitude of 53,927 km
Second Earth Gravity Assist	603	Flyby Altitude of 17,550 km
Arrival at 2016 Ho3	941	~ 2.6 years



First Earth Gravity Assist

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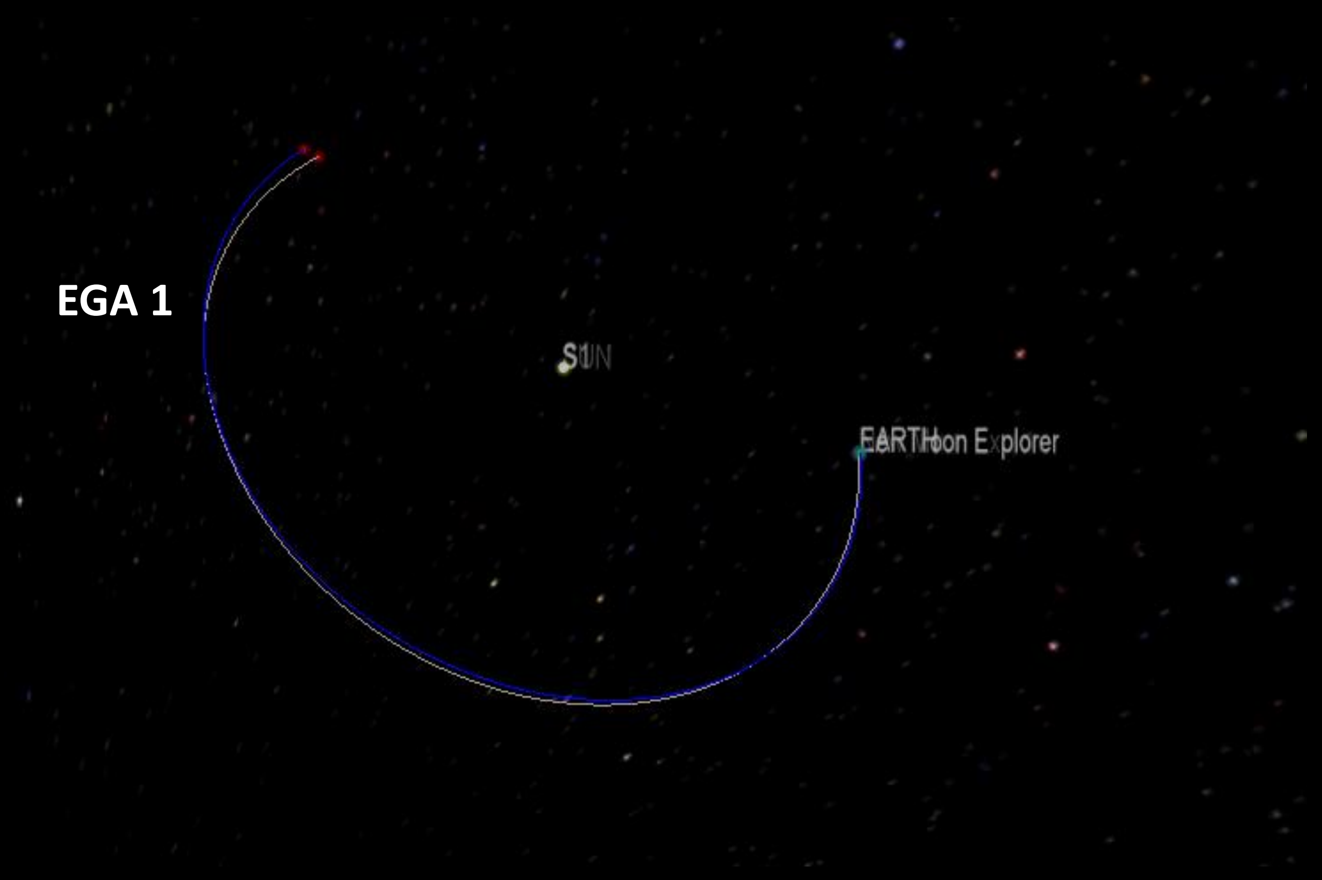

Second Earth Gravity Assist

Event	Mission Elapsed Time (Days)	Notes
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Co-Author Acknowledgements

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BACKUP

NASA's Near Earth Asteroid Scout

The Near Earth Asteroid Scout Will:

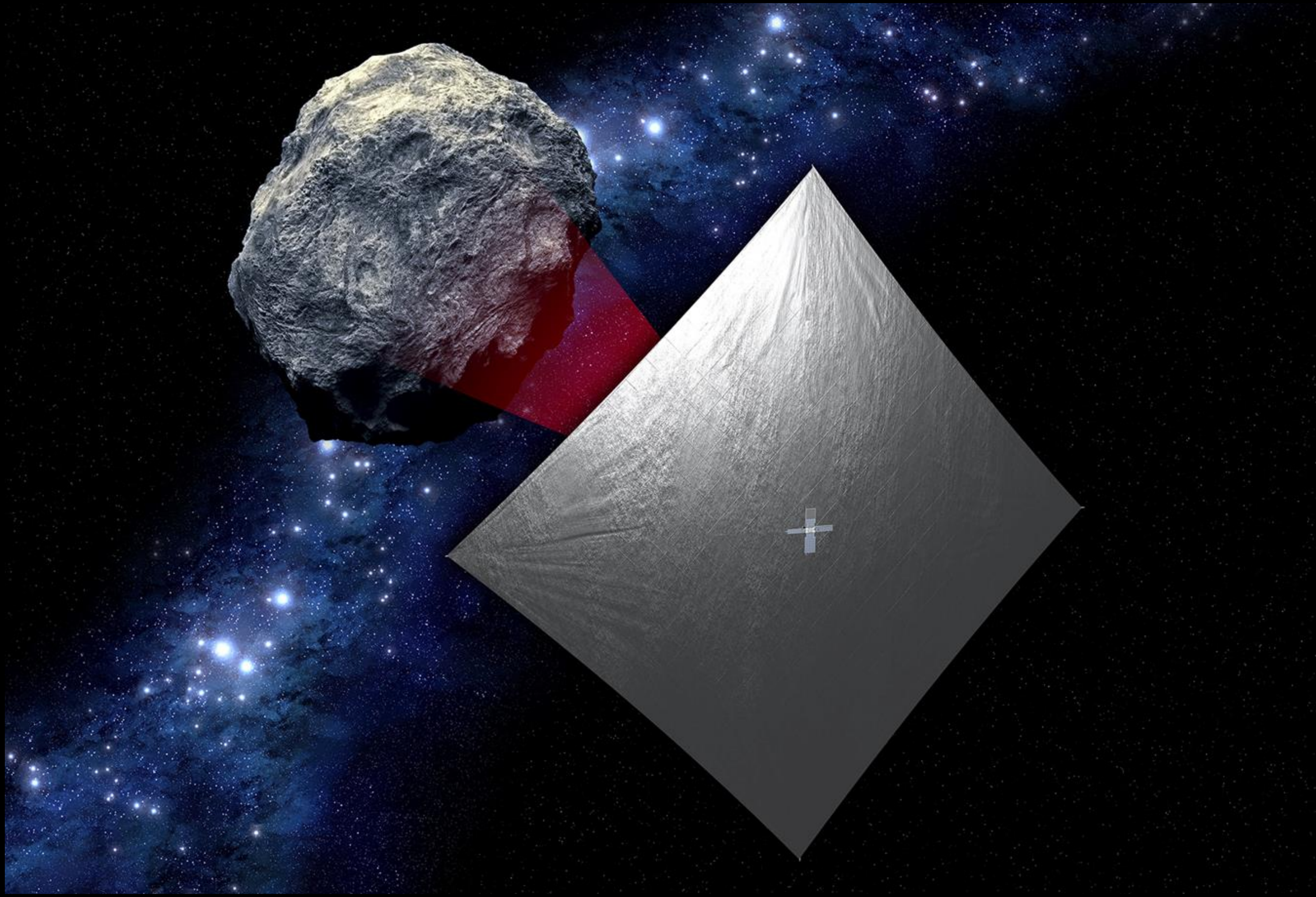
- Image/characterize a NEA during a slow flyby
- Demonstrate a low cost asteroid reconnaissance capability

Key Spacecraft & Mission Parameters

- 6U cubesat (20 cm X 10 cm X 30 cm)
- ~86 m^2 solar sail propulsion system
- Manifested for launch on the Space Launch System (EM-1/2019)
- Up to 2.5 year mission duration
- 1 AU maximum distance from Earth

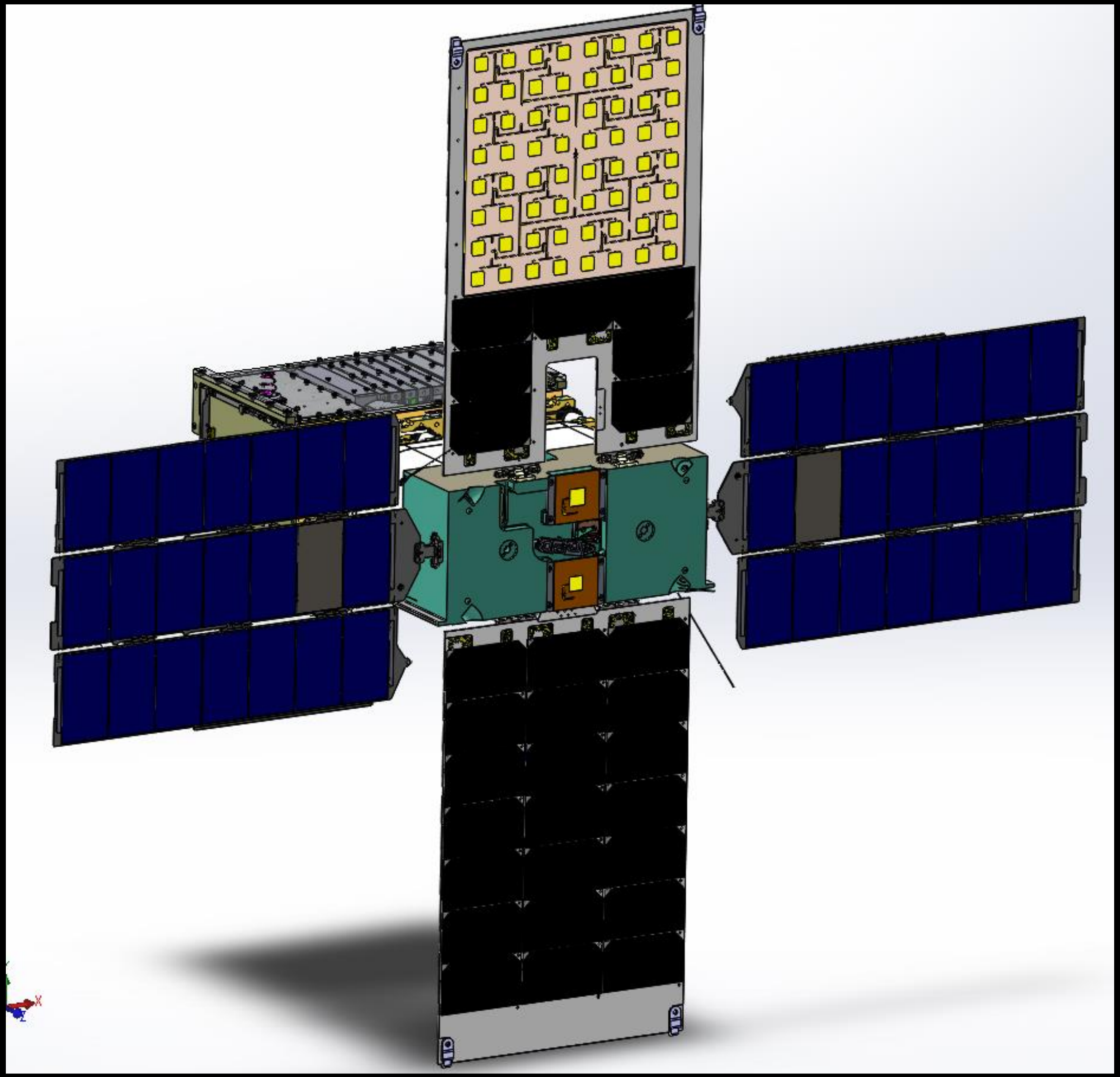
Solar Sail Propulsion System Characteristics

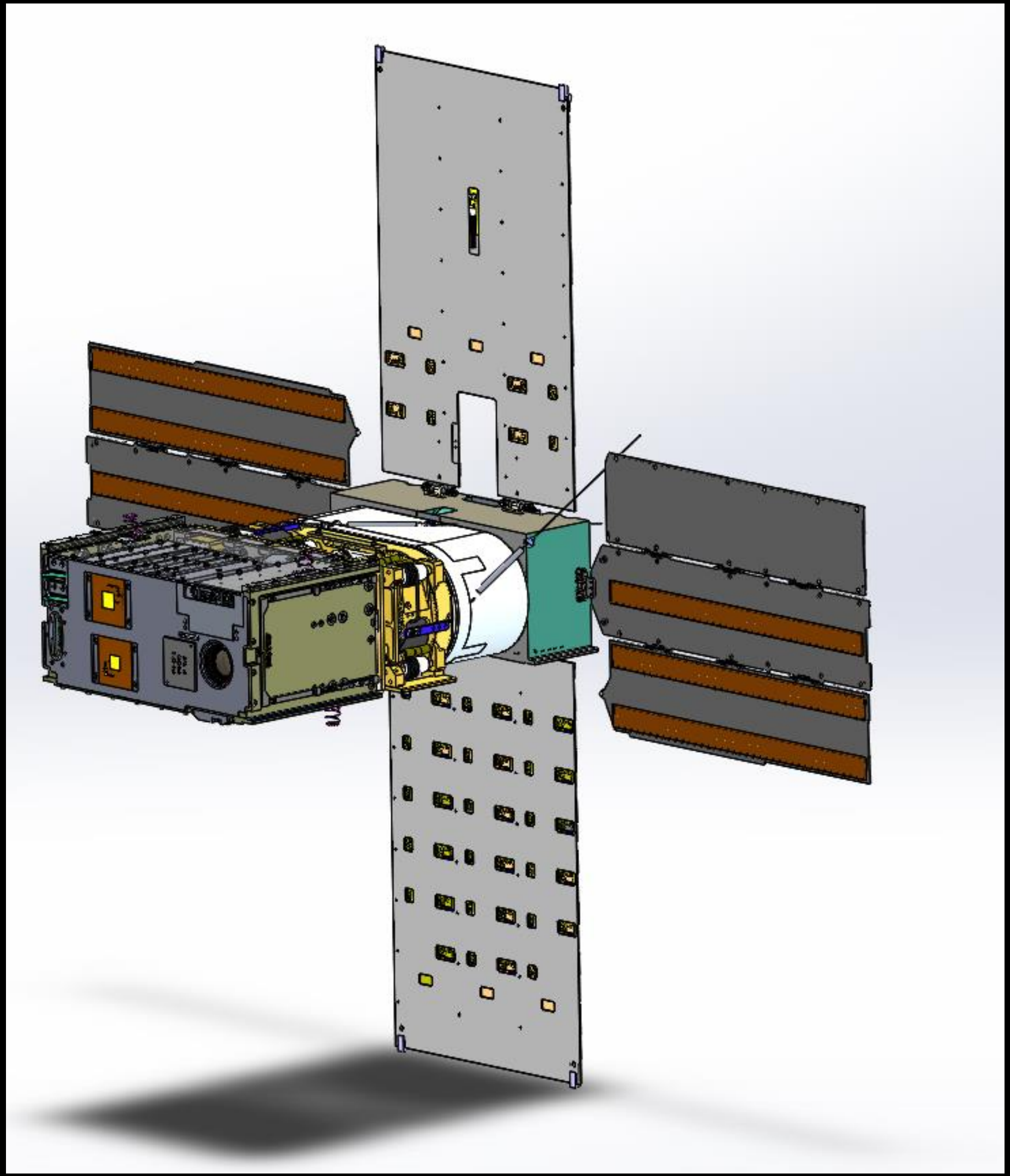
- ~ 7.3 m Trac booms
- 2.5μ aluminized CP-1 substrate
- > 90% reflectivity



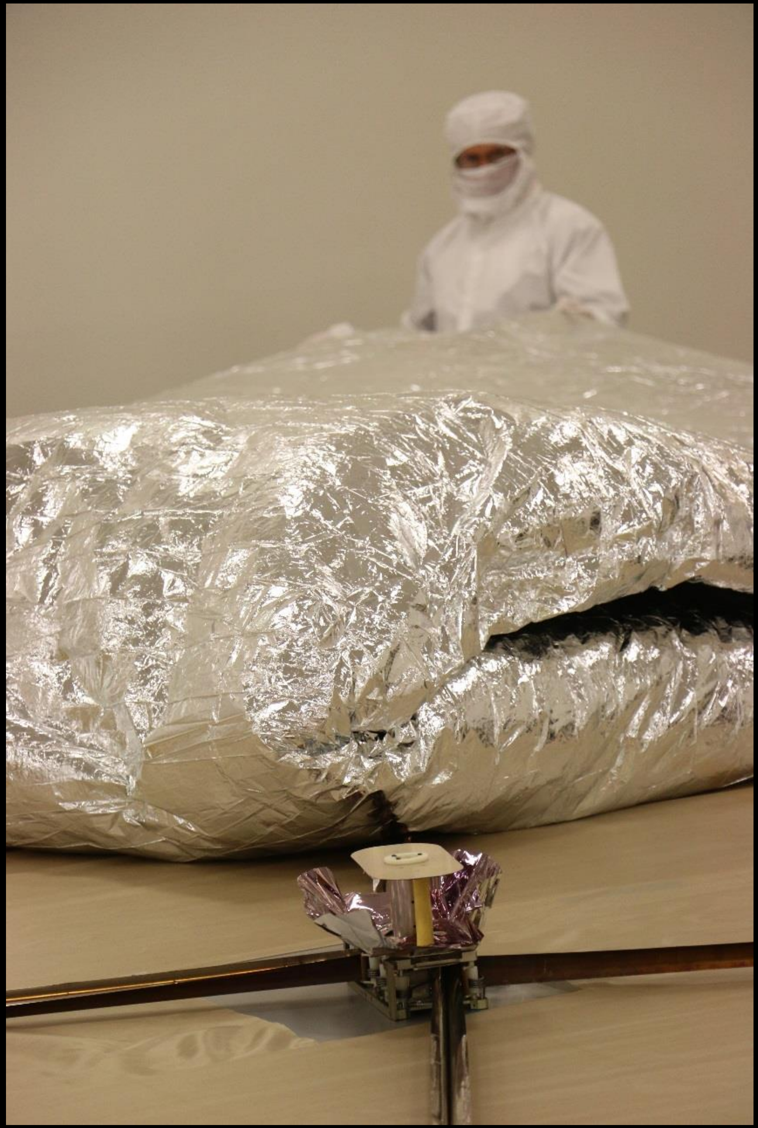
NASA Image

NEA Scout Flight System





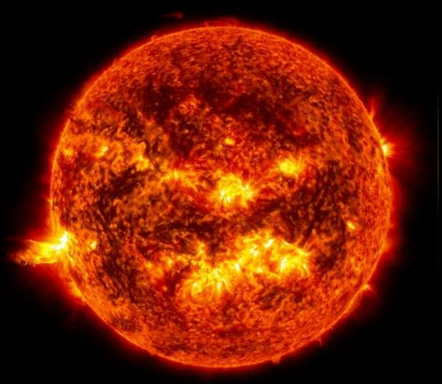
NEA Scout Hardware Overview

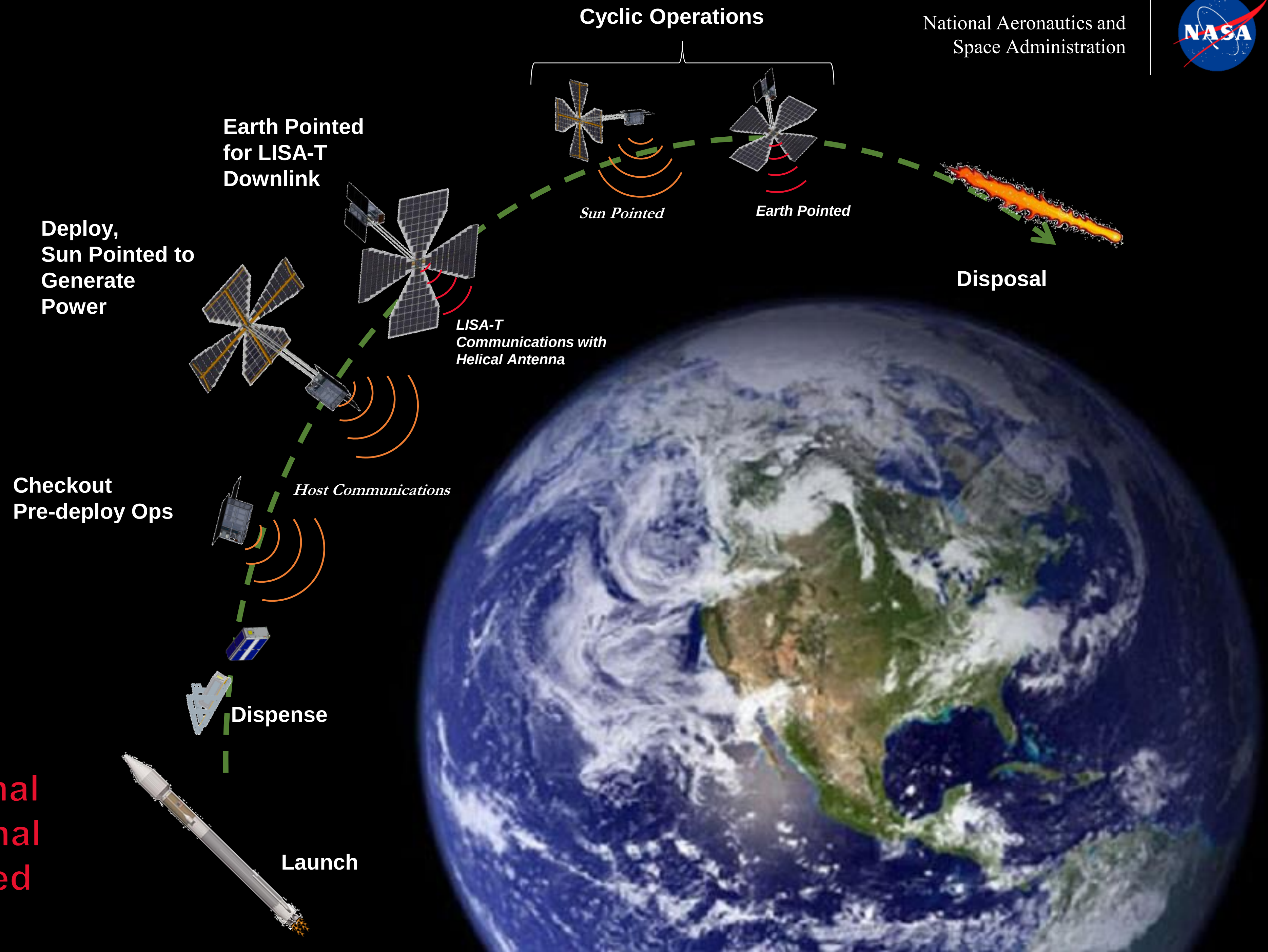


NEA Scout Full Scale Successful Deployment

NASA Image

National Aeronautics and
Space Administration





Target Duration:

1 Months minimal

4 Months nominal

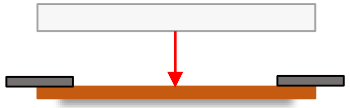
6+ Months desired

National Aeronautics and
Space Administration

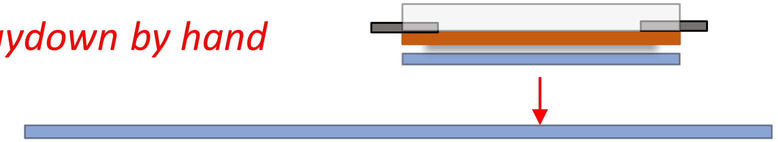
Traditional assembly:

1. Add interconnects:
Attached by hand

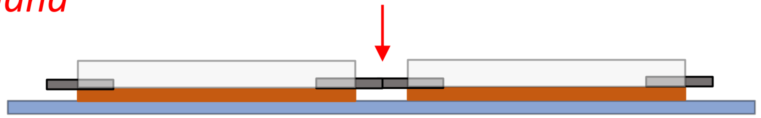
2. Cover cells
Spin by hand



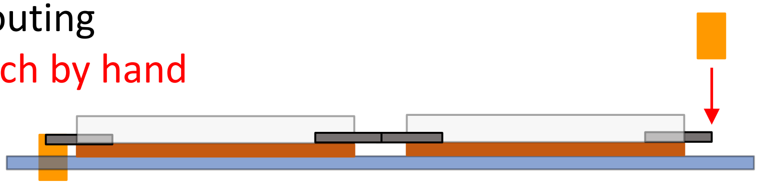
3. Bond to substrate
Spin, then Laydown by hand



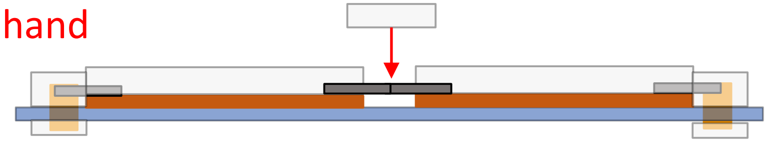
4. String Cells
Attached by hand



5. Electrical routing
Laydown/attach by hand



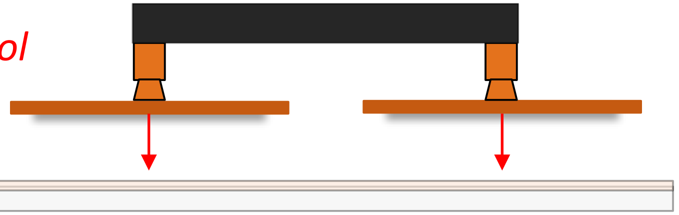
6. Electrical grouting
Insulation by hand



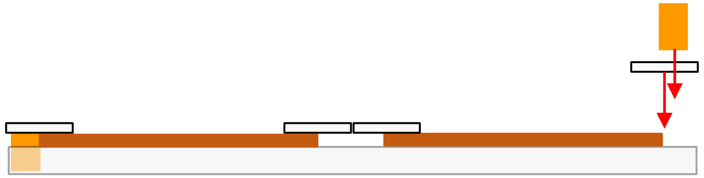
PAPA:

1. Add adhesive polymer
Laydown via print

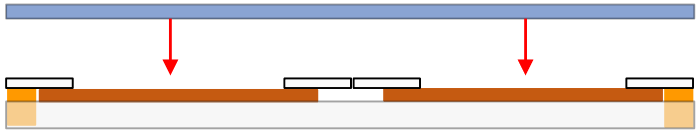
2. Place solar cells
Laydown via vacuum tool



3. Add interconnects and buses
Laydown by print



4. Add cover
Laydown via print



Payloads

- Visible imager inherited from EECAM (Mars 2020 and OCO-3 programs)
- Filter wheel assembly (color variations)
- Infrared camera (compositional variations)
  - Sensitive to 1-100 microns
  - Micro-bolometer detector
  - Modified COTS Mid-Wave Infrared (MWIR) imager
  - Stripe bandpass filters mounted on focal plane array
- Spectral type improved by Keck telescope (Hawaii)
  - Could descope filter wheel

3D View of Mission